

My Summer Internship at Kennedy Space Center

Hobert Philpott

Kennedy Space Center

Major: Mechanical Engineering

USRP Summer Session

Date: 05 AUG 11

Summary

During my summer internship at Kennedy Space Center-I worked on several projects with my mentor Grace Johnson in the Education Programs Office. My primary project was the CubeSat project in which my job was to help mentor Merritt Island High School students in the building of a CubeSat. CubeSats are picosatellites that are used to carry out auxiliary missions; they “piggy back” into orbit on launch vehicles launching primary missions. CubeSats come in the sizes of 1U (10 by 10 by 10cm) 2U (1Ux2) and 3U (1Ux3). The Cube Sats are housed in a protective deploying device called a Poly Picosatellite Orbital Deployer (P-POD). I also participated in a Balloon Workshop with the MIHS students. This was an intense 4-day project in which we constructed a balloon satellite equipped with a camera whose main goal was to obtain video images of the curvature of the earth at high altitudes and relay it back down to our ground station. I also began developing my own science research program for minority serving institutions to be implemented when funding becomes available. In addition to the projects that I completed during my internship, I got the opportunity to go on various tours of the technological facilities here at Kennedy Space Center.

CUBE SAT Project

In the Cube Sat Project I helped mentor MIHS students and worked alongside NASA mentors to complete our mission to build a 1U Cubesat to collect random vibration and shock data on a launch vehicle for the duration of the flight. Our 1U cube will be integrated with a university built 2U cube whose job is to relay our flight data back down to their ground station, and also to take a picture of our 1U cube as it is ejected from the P-POD.

There were many rules and regulations that we had to abide by while working on this project. One of the regulations that affected us significantly was that our 1U cube could neither use radio frequency or hard wire connection to communicate with the 2U cube that it would be connected to inside of the P-POD. As a result we had to come up with a wireless non radio frequency method of communication between the 1U and 2U cubes. We also had to meet weight requirements and sampling rate capability requirements.

The planning process on how to build our 1U Cube was intense and time consuming. We broke up into four subsystem groups which consisted of power, structures, command and data handling, and instrumentation. The power group is responsible for the battery and the wiring and powering of all other subsystems and components. The structures group is responsible for physically integrating all components of subsystems together inside the cube. The command and data handling group is responsible for the central microcontroller (brain) of the cube and storing and interpreting the flight data. The instrumentation team is responsible for collecting the flight data and implementing a wireless non radio frequency method of communication between the two cubes.

All subsystem groups carried out trade studies to narrow down and select the components we will order to build our Cube. I led the instrumentation team in the process of selecting components. We decided on an optical transceiver for communication between the two cubes and a tri-axial accelerometer to obtain shock and vibe data. Some specifications we had to consider while looking for an optical transceiver were cost, size, weight, power consumption, and most importantly data transmission rate. The data transmission rate specification helped us eliminate several possible optical transceivers due to the very high data transmission capabilities of optical transceivers. Some had data rates as high as 8 gigabits per second! We also had to make sure that the transceiver could be physically integrated into the microcontroller through soldered wires, pin connectors, USB etc... We also had to consider some specifications while selecting an accelerometer such as size, weight, power consumption, and measurement capabilities. Our accelerometer will be subject to forces from 0 to 100g's. After talking to engineering experts who had years of experience using accelerometers, we decided to utilize 2 accelerometers, we will set one to sample from 0 to 10 G's, and the other on to sample 0 to 100 G's. Then we will combine and interpret this data to have an accurate reading on the G forces experienced during flight. We also had to know if the accelerometer we selected was analog or digital and if it required an analog to digital converter or not. The main deciding factors that narrowed down our search for accelerometers were size and power consumption. The Infrared transceiver and accelerometer that we chose are shown below with specifications.

Infrared Transceiver Specs

TFBS4711

Vishay Semiconductors Serial Infrared Transceiver SIR, 115.2 kbit/s, 2.4 V to 5.5 V Operation

PRODUCT SUMMARY

PART NUMBER	DATA RATE (kbit/s)	DIMENSIONS H x L x W (mm)	LINK DISTANCE (m)	OPERATING VOLTAGE (V)	IDLE SUPPLY CURRENT (mA)
TFBS4711	115.2	1.9 x 3 x 6	0 to ≥ 0.7	2.4 to 5.5	0.07

FUNCTIONAL BLOCK DIAGRAM

PINOUT
TFBS4711
weight 50 mg

Definitions:
In the Vishay transceiver datasheets the following nomenclature is used for defining the IrDA operating modes:
SIR: 2.4 kbit/s to 115.2 kbit/s, equivalent to the basic serial Infrared standard with the physical layer version IrPhy 1.0
MIR: 576 kbit/s to 1152 kbit/s
FIR: 4 Mbit/s
VFIR: 18 Mbit/s
MIR and FIR were implemented with IrPhy 1.1, followed by IrPhy 1.2, adding the SIR low power standard.

Accelerometer Specs

ABSOLUTE MAXIMUM RATINGS *

5

Case Operating Temperature	-55 to +125°C
Storage Temperature	-55 to +125°C
Acceleration Over-range	2000g for 0.1 ms
Voltage on V_{DD} to GND	-0.5V to 6.5V
Voltage on Any Pin to GND¹	-0.5V to V_{DD}+0.5V
Power Dissipation	250 mW

The command and data handling, structures, and power subsystems completed their trade studies as well. We created a parts list and these parts and components are currently being ordered. The command and data handling team has received the micro-controller test board and is currently familiarizing themselves with using computer programming software. The power team is currently tackling the ongoing issue of power on methods (turning the cube on while it is on the launch pad). This has been a very challenging task because of the possibility of a launch delay that could leave our cube sitting on the launch pad for months at a time. I am currently working on test requirements to verify that all components and subsystems function properly as we are waiting on the delivery of parts. I am also helping the team in the drawings of schematics of the cube and how components will be integrated.

The Cube Sat project has benefitted me in many ways. It has helped me gain valuable engineering experience as well as valuable knowledge about the engineering design process and systems engineering. I have also learned the importance of communication skills when working with others. Most importantly I gained leadership experience by mentoring high school kids and leading them in the right direction to complete their tasks.

Balloon Workshop

At the start of the Cube Sat project, my team of NASA mentors and MIHS students participated in an intense 4- day hands on engineering experience called the Balloon Workshop. The purpose of this mission was to help the high school students gain a better understanding of how to work together to complete an engineering task. Our task in this mission was to create a payload equipped with a camera, temperature sensor, parachute, GPS, and communications antennae. This payload would be attached to a latex balloon and lifted 100,000 feet into the air where it would then pop and fall back to the ground. The primary goal of our mission was to capture video images of the curvature of the earth at high altitudes and relay it back down to our ground station that was set up at the KSC's Visitor's Complex. We also obtained temperature and GPS location data and relayed this data down to the ground station as well. All materials and supplies we used were located inside the lab.

We broke up into 3 subsystems groups similar to the organizational structure of the CubeSat project. The box group was responsible for making the box that the camera and other electrical components would be housed in. The box also had to be properly insulated to maintain an internal temperature threshold so that all electrical components could function properly. The stabilization crew was responsible for preventing the box from spinning and swaying during ascent. This was a very challenging task as the box would encounter wind speeds of up to 100 miles per hour. This subsystem was also responsible for creating the parachute. The third system was the electronics group. This was the largest group because they were responsible for securely integrating all electrical components inside the box, as well as setting up the ground station for

communications. All subsystems collaborated together to meet deadlines. We only had 4 days to build and test our payload before launch.

Payload



I worked with the stabilization group. The very first thing we did was each of the three people of the group brainstormed as many stabilization devices and ideas as we could. Then we negotiated together what would be the best two to test. The two devices that we choose were a “wind sock” and a “stabilization wing”. We planned to test these two devices by attaching them to a test box similar in size and shape to our actual box, by hanging the box from a high ceiling in the lab using a string and utilizing fans to simulate the wind. We created the stabilization wing by cutting out a rectangular flap from a piece of card board. We then attached the piece of cardboard to the back of the test box.

Testing Procedure (Stabilization wing)



To create the wind sock, we used a nylon home depot bag. We cut 4 rectangular sheets of material from the bag of equal size and attached them to a circular piece of Styrofoam. Then we used 4 equal length pieces of string to integrate the windsock onto the back of the second test box. After testing these two devices the wind sock proved to be the most effective. The stabilization wing would spin out of control from side to side depending on the direction

that the fan was blowing. The wind sock would align itself in the direction that the wind was blowing and stabilize itself. My secondary task during the Balloon Workshop was to create the parachute for the satellite. I had to meet the requirement of slowing the payload down to the safe descent speed of no faster than 15ft per second. I used a parachute formula to determine what the diameter of my parachute should be.

Balloon Diameter Formula

$$A_p = \frac{2gm}{\rho C_d V^2}$$

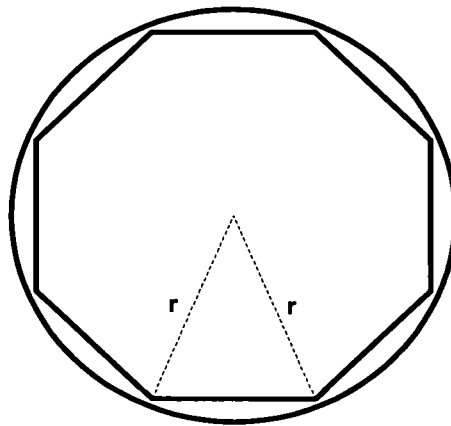
g= the acceleration due to gravity, 9.81 m/s² at sea level

m = the mass of the rocket (propellant consumed)

ρ = the density of air at sea level (1225 g/m³)

C_d= the coefficient of drag of the parachute – estimated to be 0.75 for a round canopy

V = the descent velocity of the rocket, 11 to 14 ft/s (3.35 m/s to 4.26 m/s) being considered a safe descent speed.



A₀= 8A_T , where A_T is the area of the triangle and A₀ is the area of the octagon.

After plugging in the variables and doing some calculations, I determined that the diameter of my parachute should be 70 inches. I connected 8 strings of equal length to the parachute that were all 35 inches long, half the diameter of the parachute to ensure that it would open properly. We tested the parachute by dropping it down from one of the high ceilings in the lab and everything worked as planned as the parachute opened successfully.

Our mission was an overall success. All subsystems groups had met their deadlines and on launch day we were ready. Take off went smoothly and the stabilization device worked to perfection. We got clear video feed and the temperature sensors and GPS worked correctly. The insulation of the box functioned properly and maintained safe temperatures inside the box. The ground station maintained communications with the payload for the majority of the flight and only lost signal once for a short duration. We accomplished our goal of obtaining video images of the curvature of the earth at high altitudes. Our payload made it to the height of approximately 97,000 feet and recorded temperatures as low as -70 degrees Celsius before the latex balloon ruptured and our payload began its decent. Shortly after the balloon ruptured we encountered some issues with the parachute. Judging by the video feed, the payload tumbled violently on the way down, thus tangling up the parachute and causing it not to open properly.

The payload fell to the ground in a fraction of the time it was designed to fall. We had video feed all the way until final impact as our payload crashed into a patch of trees near central Titusville. A search and recovery team set out to locate the payload but failed to recover it. The Balloon Workshop was an overall success and was very beneficial to my team and me. It showed us the importance of communicating with each other while working together to meet a common goal. It also stressed the importance of meeting deadlines and working in a timely fashion. It also reinforced the importance of testing methods and being prepared for the unexpected. Most importantly the Balloon Workshop helped the high school students gain an understanding of the engineering design process and how different subsystems come together to get the job done. Also by completing this project we as a team gained valuable knowledge and were much better prepared to tackle the Cube Sat project.

MARSE Project (Minority Academic Research for Space Exploration)

During my summer internship at KSC I also got the opportunity to work with my mentor on designing an undergraduate research program for minority serving institutions. The Minority Academic Research for Space Exploration project is geared toward helping minority serving institutions to participate in research and technology development needed to produce advanced space-flight systems for future planetary and solar system exploration. The project will be beneficial to both the students who participate and the University in which they attend. It will benefit underrepresented students by providing them with hands-on experience in planetary science research and how to behave in a professional work environment. The program will benefit the University by strengthening its research in the areas of science and technology. It will encourage students already pursuing careers in Science Technology Engineering Math (STEM) fields to retain interest and expose students to opportunities that support NASA's strategic goals, and ultimately help NASA advance technologies in planetary science and space exploration. The research in this program will focus specifically on solar electric technology and finding ways to increase their efficiency for long term deep space missions. The project is currently in the developmental phase and there is a substantial amount of work to be done before it can actually be implemented. I also keep in close contact with college professors to gain feedback on how I should go about structuring the project

Experiences/Outlook

During my time at KSC I got the opportunity for many experiences that most people don't get to experience in their lifetimes. With the closing of the shuttle program I got to see some amazing things for the last time in history. I witnessed the launch of Space Shuttle Atlantis, the last space shuttle launch in history. It was my first time witnessing a space shuttle launch and it was truly an amazing experience. I even got the chance to witness the landing of Atlantis and hear the sonic booms which was also fascinating. I also got the opportunity to go on many tours of the technological facilities here at KSC. I had the chance to see the Vehicle Assembly Building, Shuttle Processing Facility, and even the launch pad. I actually got the chance to walk up onto the launch pad while Space Shuttle Atlantis was awaiting launch day which was truly a breathtaking experience. I also got the opportunity to speak with Mechanical Engineers and see firsthand what they do on the job. I gained a wealth of knowledge while here at KSC. I have a better understanding of engineering and what engineers actually do on the job. The engineering experience I gained while working on the various projects that I mentioned before is invaluable and has better prepared me for my future in engineering. But most importantly it has showed me first hand that I really can do what I put my mind to and reassured me that engineering is what I really want to make a career out of. This was truly the experience of a lifetime.